Space Weather Technical Forecast

Issued on Tuesday, 12 September 2023 at 01:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further M-flares likely (R1-R2 radio blackouts). Chance of G1 Minor storms day 1 (12 Sep).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate, with three M-class flares observed in the last 24 hours. The strongest of these was an M1.3 flare from AR3429 at 11/0128 UTC in the northeast quadrant. Two M1.1 flares were also observed from AR3431 peaking 11/0407 UTC and 11/1448 UTC from AR3431. AR3429 is a small region, but has seen some development of trailer spots. AR3431 however has simplified a little, losing its delta configuration, while persisting as a small spot. This does still have some potential instability however with an east-west neutral line. AR3423 in the northwest remains the largest region, however this appears to have stabalised with few dynamical changes. AR3425 however, despite decreasing in overall size, developed a weak delta spot with an opposite polarity emergence to the southwest of its trailer. The other regions are smaller and simpler, with ten regions currently on the disc.

A filament eruption and associated coronal dimming was observed around 11/1400 UTC off the southwest disc. The subsequent CME was faint, heading south, and partially obscured by an earlier halo CME that was assessed as far-sided. Analysis is ongoing, however.

Solar Wind / Geomagnetic Activity: Slow wind was observed at L1 by ACE/DSCOVR throughout, although the wind speed did increase from background at around 350km/s to be slightly elevated at 400 km/s. The density persisted below background for much of the period, with an increase to average levels was observed 11/2200 UTC, rising to 10ppcc. It is currently too soon to know the source of this increase. The Interplanetary Magnetic Field (IMF), Bt, was mainly weak and below 9nT throughout with north-south component, Bz, weak and variable between +/- 6nT. Phi angle was mostly negative (towards the Sun). Geomagnetic activity was Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux has been at background. GOES16 high energy (greater than 2MeV) electron flux was at background. The associated 24-hour fluence was well below the Active threshold, with 2.74e6 integrated pfu observed at 12/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Moderate to Low, with further isolated M-flares likely.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs in the forecast, however the filament eruption on 11 Sep is still under analysis. The coronal hole and subsequent solar wind and geomagnetic activity forecast is low confidence. This is due to a lack of enhancement from CH44/+ from a similar position on the previous rotation. However this feature is in a good location for a high speed stream (HSS) to arrive at Earth day 1 (12 Sep), with solar winds around 500-600km/s. Enlil is also reducing confidence with a much stronger and earlier arriving coronal hole, but from a more central located feature likely CH46/-. This is currently not expected to enhance winds at Earth, however an enhancement is more likely from

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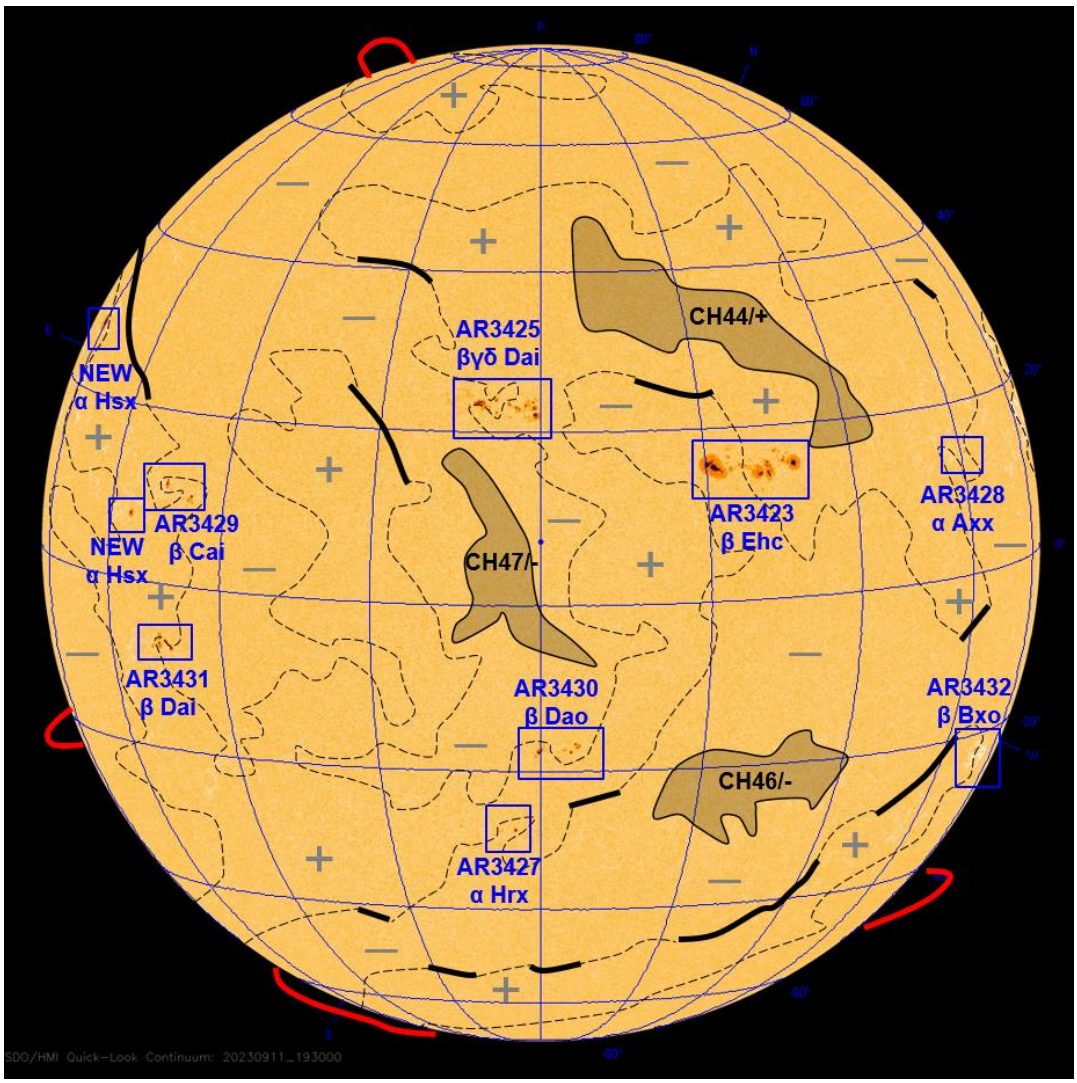
the more western feature CH47/- on day 3 (14 Sep). Consequently current Quiet geomagnetic activity is forecast to become Unsettled to Active with a chance of G1 Minor Storms day 1 (12 Sep), easing to Quiet to Unsettled day 2 (13 Sep), before increasing again day 3 (14 Sep), with a chance of Active intervals.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to remain at background levels, with a very slight chance of an enhancement should any larger flares occur. High energy (greater than 2 MeV) electron flux is expected to be at background day 1 (11 Sep), then likely responding to the fast wind arrival, and increasing to Moderate to High later day 2 (13 Sep). Confidence is then Low, however any subsequent solar wind enhancement has the potential to drop out flux day 3 (14 Sep). Overall, the fluence is expected to remain below the Active threshold, but with a slight chance of rising above.

Figure 1. Solar Analysis Valid 11/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs, however a weak filament eruption from the south-centre disc on 11 Sep is still being assessed. This appears slow and relatively faint in imagery, with at most a glancing impact possible later in the period.

CH44/+ in the most likely source of any significant enhancement. Based upon the location of the feature, onset of the fast winds from this feature are expected through day 1 (12 Sep) and given its Russell-McPherron favoured polarity at this time of year, some level of geomagnetic disturbance is likely. However, this feature was in a similar location on the Sun on the previous 27-day rotation and yet Earth saw no enhancement from its associated HSS.

Conversely Enlil already has enhanced solar winds from before day 1 (12 Sep), which is from a more southern or centrally located hole, likely CH46/- in the southern disc. However, Earth is located around 6N of the elliptic plane, and more likely to connect to northern hemisphere features, suggesting a better chance of enhancement from CH47/+. Furthermore, the only enhancement observed on the previous 27-day rotation was on the equivalent of late day 2 through day 3 (13-14 Sep). While this did have a negative phi angle, with some potential of being from CH46/-, this was more likely due to a small crack in the corona, which has subsequently developed into CH47/-. The bulk of this coronal hole is now slightly further east compared to the previous rotation, and likely to enhance solar winds on day 3 or 4 (14-15 Sep). This is of negative polarity, so unfavoured for a strong geomagnetic interaction.

This creates a complex forecast, with a variety of potential coronal hole interactions, and little of assistance from either enlil or persistence for gaining confidence in the likely outcome.

Overall, current Quiet conditions are expected to continue until the arrival of any CIR, likely associated with CH44/+, day 1 (12 Sep). A spell of Unsettled to Active geomagnetic activity is forecast due to this, with a chance of G1 Minor Storms. Activity then easing back to Quiet to Unsettled day 2 (13 Sep), before a further enhancement is possible, most likely day 3 (14 Sep) with a transition into any fast wind from CH47/- bringing further Active intervals, and a slight chance of G1/Minor Storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	5	10	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Figure 2a: SDO aia-211 last rotation and current

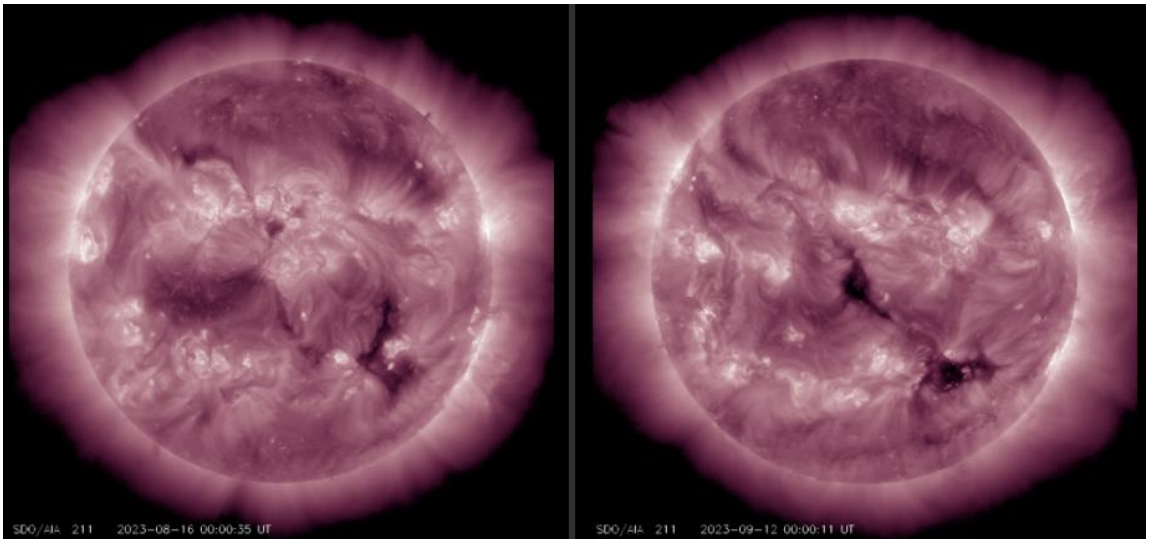


Figure 2b: Solar Wind Persistence Model

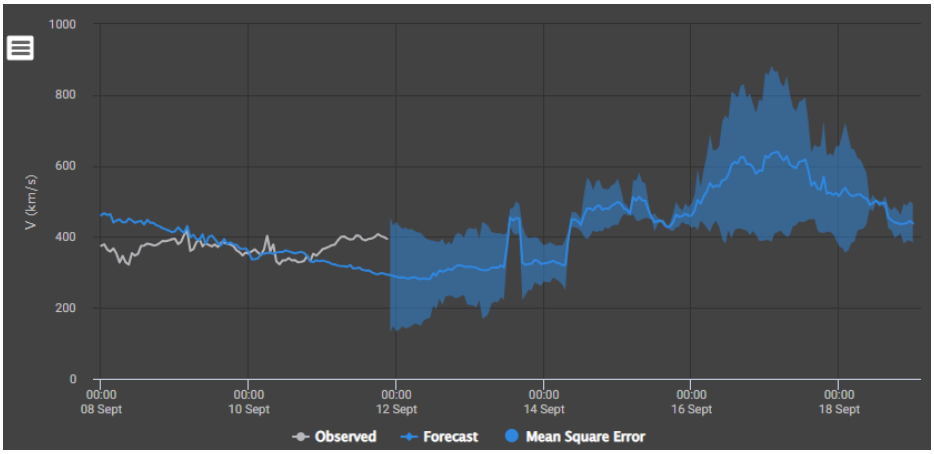
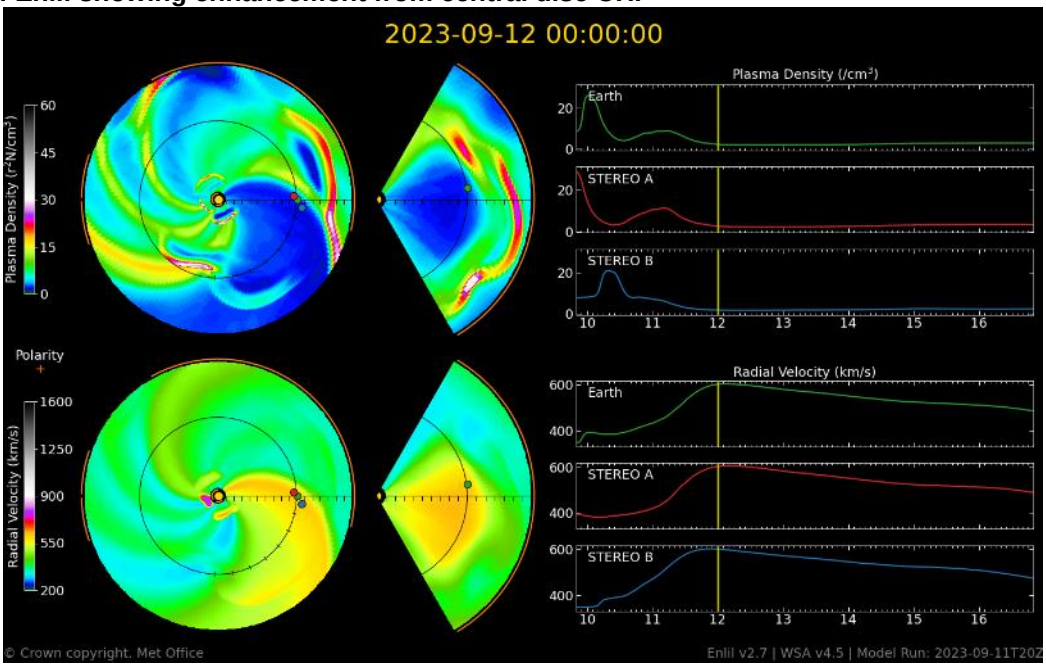


Figure 2c: Enlil showing enhancement from central disc CH.



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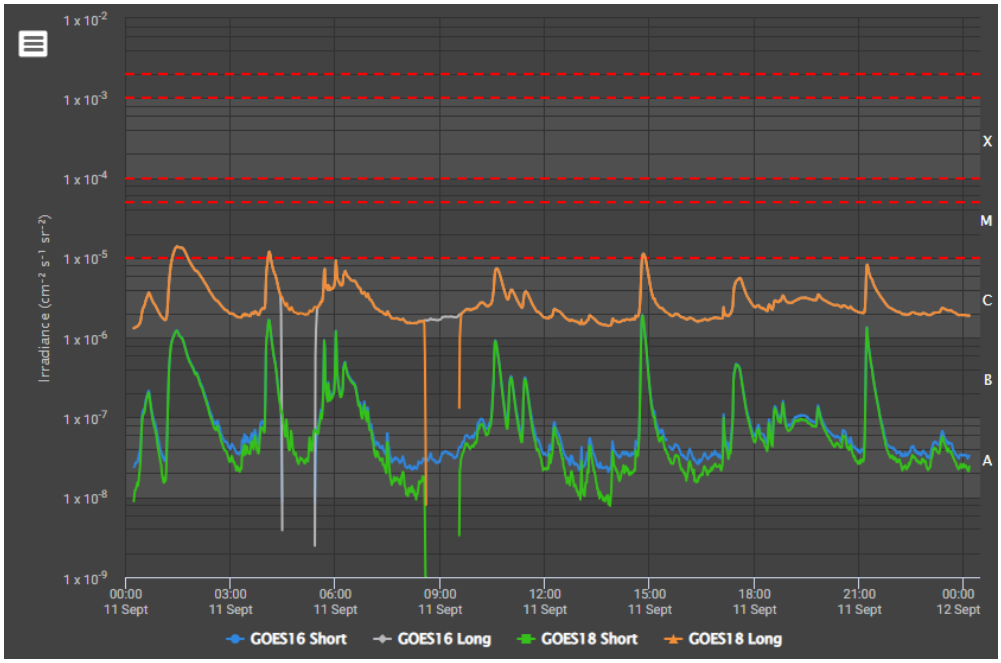
Radio Blackouts - X-Ray Flares:

Moderate to Low activity is expected to continue with an ongoing likelihood of isolated M-class flares.

There are ten active regions visible on the disk, the majority of which have been either stable or decreasing in complexity in the last 24 hours. The exceptions are AR3429 in the northeast, with a small growth in trailer and intermediate spots, and also AR3425 which is now approaching the northern centre disc. Despite not increasing in areal extent, this has seen the emergence of a small opposite polarity region besides its trailer, developing a small and weak delta spot. AR3423 in the northwest remains the largest spot on the disc, but has produced only very minor flare activity. AR3431 has simplified a little, losing its delta configuration. However, this still likely has some instability due to its east-west parity separation line. The other regions remain smaller and simpler and less likely to produce notable flares.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/18 X-ray Flux



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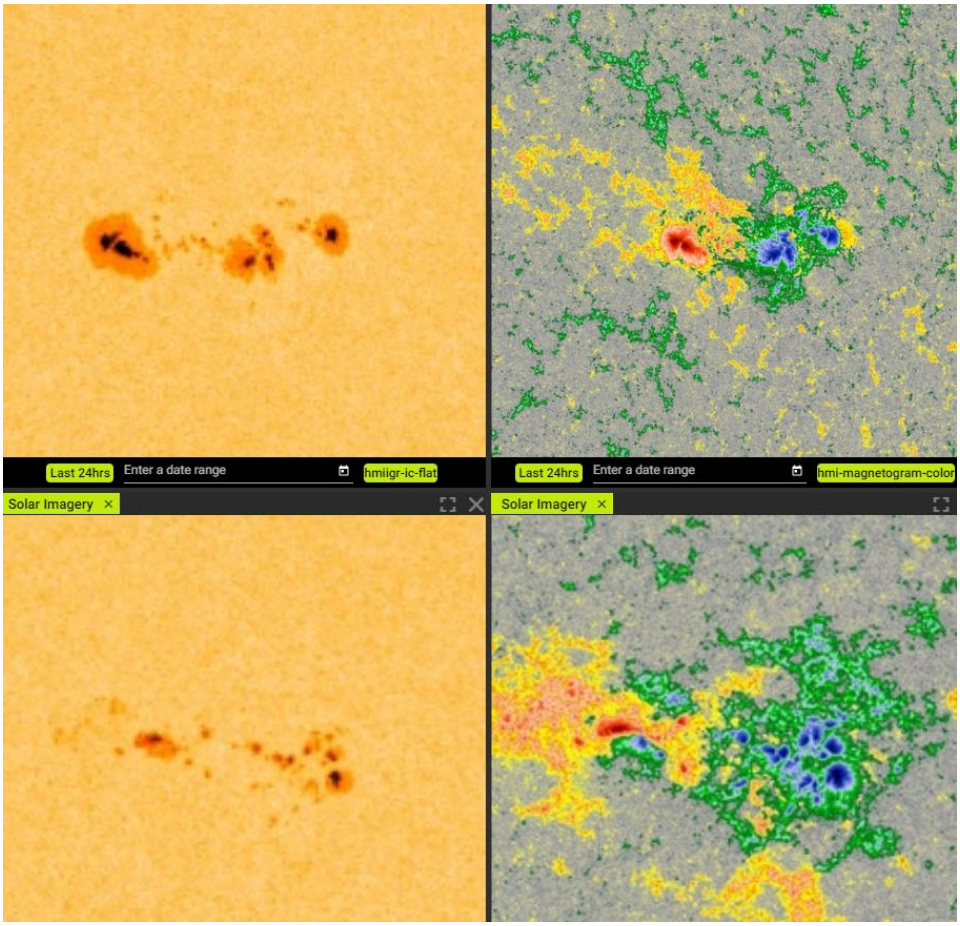
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at background levels. There remains a very slight chance of flux levels rising in response to any significant flaring as AR3423 and AR3425 continue to move across the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO Intensitygram and Magnetogram of AR3423 (top) and AR3425 (bottom)



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High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux observed by GOES-16 is expected to remain at background day 1 (12 Sep). Any coronal hole fast wind arrival from CH44/+ has the potential to increase the flux through the Van Allen belts, and observed values at GEO are likely to increase later day1 or more likely day 2 (12-13 Sep), rising to Moderate, perhaps High at diurnal peak. However this rise is low confidence, with the potential for further solar wind enhancement to disrupt the belts, and lead to a drop out in observed flux. This is most likely to occur day 3 (14 Sep), before a recovery to Moderate on day 4 (15 Sep).

The associated 24-hour fluence will most likely remain below the Active (1e8 integrated pfu) threshold. Confidence for this decreases day 2 onward, with a slight chance of rising above, depending on both the strength of the initial enhancement from CH44, but also the length of time until any drop out occurs from any subsequent enhancement. MOSWOC REFM is considered to be giving good guidance until the onset of any fast winds.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	20	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES 16 >2meV Electron Flux and Fluence with REFM.

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